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A new species of the genus *Murina* (Chiroptera, Vespertilionidae) from the Southeastern Qinghai-Tibetan Plateau, China

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Abstract

The tube-nosed bats (genus *Murina*) are small insectivorous mammals that are primarily distributed in South, East, and Southeast Asia. The Qinghai-Tibet Plateau (QTP) has long been an understudied region in bat surveys, especially for species of small arboreal bats, including *Murina*. In 2023, we surveyed the southeastern QTP and collected seven individual specimens of *Murina*. The specimens were identified using combined morphological and molecular data (the mitochondrial Cyt *b* gene). Phylogenetic analyses identified three unknown clades: *Murina* sp1, *Murina* sp2, and *Murina* sp3. *Murina* sp1 was most closely related to *M. pluvialis*, with a genetic distance of 0.09. *Murina* sp2 was most closely related to *M. shuipuensis*, with a genetic distance of 0.13, and *Murina* sp3 was most closely related to *M. chrysochaetes*, with a genetic distance of 0.15. All three species delimitation methods supported the partitioning of *Murina* sp1, *Murina* sp2, and *Murina* sp3. Herein, we describe a new species, *Murina chayuensis* **sp. nov.** (*Murina* sp1.), that is similar to *M. annamitica* and *M. lorelieae*. Owing to the limited number of specimens, *Murina* sp2 and *Murina* sp3 are not described in this study. Our results highlight the overlooked diversity of bats in the southeastern QTP, and thus this group warrants further surveys and taxonomic studies.

Key Words

Cyt *b*, morphology, taxonomy, tube-nosed bats

Introduction

The genus *Murina* Gray, 1842 (Chiroptera: Vespertilionidae) is characterized by tubular nostrils and the back of the interfemoral membrane being covered with hair. The species occur in South, East, and Southeast Asia, including Vietnam, Laos, Malaysia, India, China, and others (Wilson and Mittermeier 2019). Historically, *Murina* species have been infrequently documented in systematic collections and seldom observed in the wild (Csorba and Bates 2005). Nevertheless, significant advances in the taxonomy of *Murina* bats have been made through the extensive use of harp traps, re-evaluation of morphological and cranial characteristics, and species delimitations based on DNA barcoding and acoustic data (Francis et al. 2010). Over the last two decades, 23 new species of *Murina* have been described (Simmons 2005; Wilson and Mittermeier 2019; Yu et al. 2020; Mou et al. 2024; Wang et al. 2024), with 12 Murina species identified in southern China: *M. bicolor*, *M. gracilis*, *M. recondita*, *M. chrysochaetes*, *M. lorelieae*, *M. shuipuensis*, *M. fanjingshanensis*, *M. rongjiangensis*, *M. liboensis*, *M. jinchui*, *M. yuanyang*, and *M. yushuensis* (Kuo et al. 2009; Eger and Lim 2011; He et al. 2015; Chen et al. 2017; Zeng et al. 2018; Yu et al. 2020; Mou et al. 2024; Wang et al. 2024).

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Mountainous regions, although covering only approximately one-eighth of the Earth's land surface, host nearly one-third of global terrestrial species (Spehn et al. 2012; Rahbek et al. 2019). The Qinghai-Tibet Plateau (QTP), famously dubbed "the roof of the world," is the highest, most extensive, and youngest massif (Zhang et al. 2002). Recognized as a global biodiversity hotspot (Myers et al. 2000), the QTP harbors 250 species of mammals from 30 families, including first-category protected species such as *Equus kiang*, *Moschus chrysogaster*, and *Bos mutus* (Huang et al. 2008). Despite this rich biodiversity, bats (Chiroptera), a group second only to rodents (Rodentia) in mammalian species diversity (Wilson and Mittermeier 2019), account for only one-tenth of the region's recorded species (Feng et al. 1986; Huang et al. 2008).

To gain a comprehensive view of the distribution and diversity of bats within the QTP, we surveyed the region, obtaining seven individual specimens of *Murina* from the southeastern QTP. These specimens represented three distinct taxonomic units and exhibited notable dissimilarities in appearance compared with other species of *Murina* found in China. Because only one specimen was available for each of *Murina* sp2 and *Murina* sp3, in this study, we describe only *Murina* sp1.

Materials and methods

Sample collection

In August 2023, seven specimens were collected in Chayu County (28°29'51.12"N, 97°0'53.87"E, 1511 m above sea level) and Luozha County (28°6'18.73"N, 91°7'22.40"E, 3292 m above sea level) using harp traps (Fig. 1). These specimens were significantly different from the *Murina* species known to occur in China based on morphological characteristics and fur color Six specimens collected from the mid-low elevation area of Chayu County were assigned to two putative new species (*Murina* sp1: XZ2023085, XZ2023086, XZ2023088, XZ2023100, and XZ2023107, and *Murina* sp2: XZ2023094). A specimen collected from Luozha County was assigned to a third putative new species (*Murina* sp3: XZ2023048). The bat specimens were preserved in anhydrous ethanol and stored at the Guizhou Normal University, Guiyang, China.

Phylogenetic analysis and species delimitation

To identify the bats, DNA was extracted from a small area of the wing membrane of each bat, followed by polymerase chain reaction (PCR) to amplify a portion of the mitochondrial cytochrome *b* gene (Cyt *b*) using the primers Cyt b-F (5′-TAG AAT ATC AGC TTT GGG TG-3′) and Cyt *b*-R (5′-AAA TCA CCG TTG TAC TTC AAC-3′) (Li et al. 2006). Each PCR was conducted in a 50 µl volume containing 8 µl of genomic DNA, 2 µl each of primers F and R (10 mM each), 13 µl of water, and 25 µl of HiFi DNA polymerase master mix. The PCR conditions were as follows: 5 min at 94 °C, followed by 10 cycles of 60 s at 94 °C, 30 s at 46 °C, and 62 s at 72 °C; 25 cycles of 60 s at 94 °C, 40 s at 50 °C (+0.3 °C/cycle), and 60 s at 72 °C; 35 cycles of 60 s at 94 °C, 40 s at 54 °C, 60 s at 72 °C, and final elongation for 10 min at 72 °C. All newly obtained sequences have been submitted to GenBank (Appendix 1).

We collected 40 Cyt *b* sequences from *Murina* species and relevant outgroups from NCBI for phylogenetic reconstruction in combination with the obtained sequences (Appendix 1). All sequences were aligned using MUSCLE in MEGA 7.0 (Edgar 2004; Kumar et al. 2016). Selection of the best-fit nucleotide substitution model was performed using MrMtgui (Ma 2016). MtMrgui was used to implement PAUP, ModelTest, and MrModelTest across platforms. The phylogenetic tree was constructed using Bayesian inference (BI) in MrBayes 3.2 (Ronquist et al. 2012). Genetic distances based on the Kimura 2-parameter model were estimated using Cyt *b* in MEGA 7.0 (Kumar et al. 2016).

Three molecular species delimitation methods were used to aid in species definitions. Assemble species by automatic partitioning (ASAP) enables rapid assessment of species boundaries based on sequence differences (Puillandre et al. 2021). Bayesian implementation of the Poisson tree process (bPTP) and multi-rate Poisson processes (mPTP) are two tree-based methods for defining species boundaries (Zhang et al. 2013; Kapli et al. 2017). First, we performed ASAP analyses using the ASAP online server (https://bioinfo.mnhn.fr/abi/public/asap/) with the Kimura distance model for the Cyt *b* sequences. We set the average ratio between transitions (ts) and transversions (tv) estimated using the Kimura 2-parameter model in MEGA 7.0 (Kimura 1980; Kumar et al. 2016), and then selected the best ASAP score to define the optimal number of species partitions. Second, the bPTP analysis was performed using the bPTP online server (https://species.h-its.org/). We ran 100,000 Markov chain Monte Carlo generations with a thinning of 100 and an initial burn-in of 10%. The input tree for the Cyt *b* gene was generated using MrBayes 3.2 (Ronquist et al. 2012). Finally, we employed mPTP using the online server at https://mptp.h-its.org/ based on the same input tree as for bPTP and default parameters.

Morphological analysis and measurements

External and craniodental measurements of the bats were taken using electronic digital calipers to the nearest 0.01 mm according to the method of Bates and Harrison (1997). Eight adult bats were examined in terms of the 15 measurements of Ruedi et al. (2012). Abbreviations for morphological characters are as follows: FA, forearm length; E, ear length; GTL, greatest length of skull;

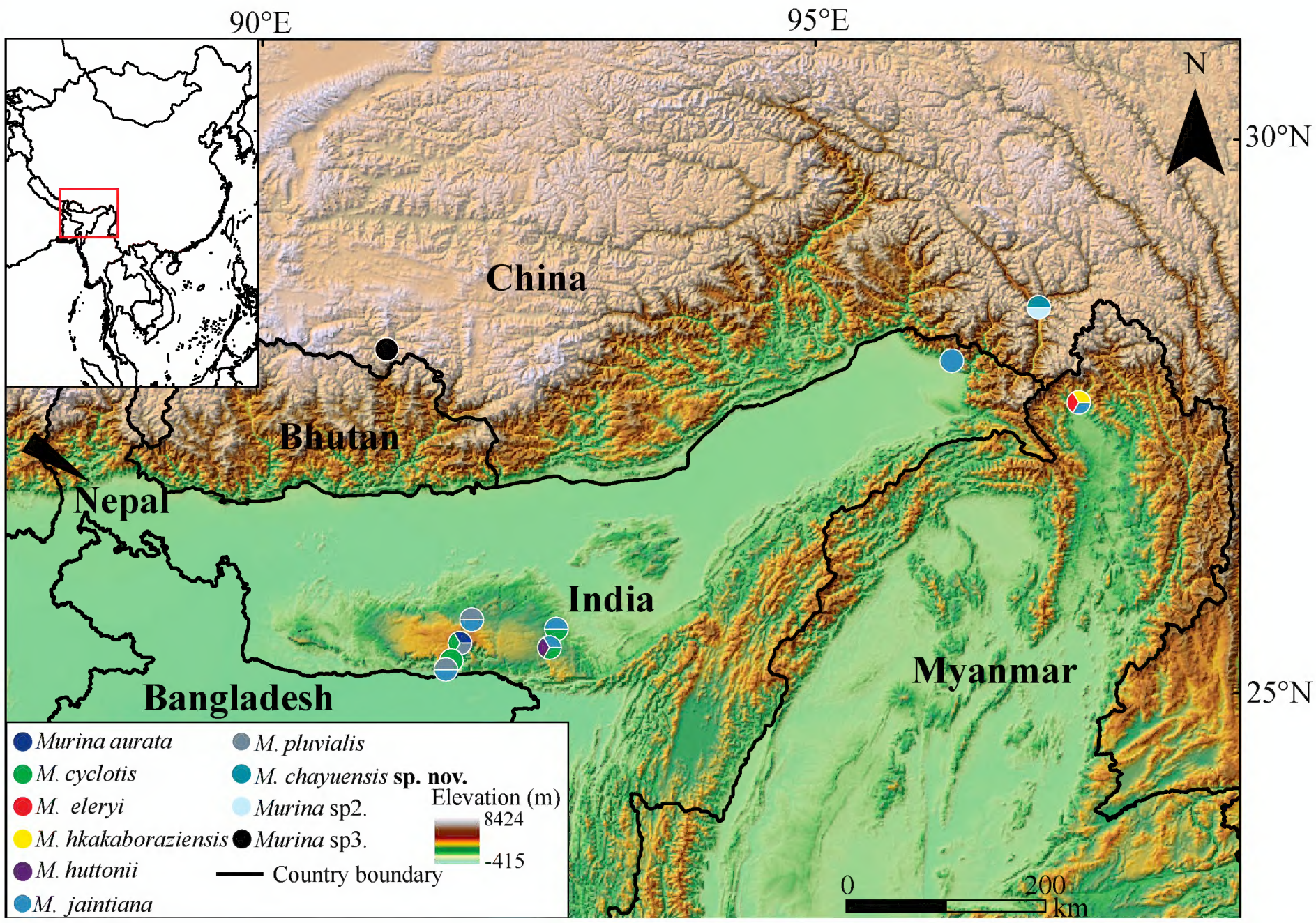

Figure 1. Occurrence of *Murina* species in the southeastern Qinghai-Tibetan Plateau and neighboring areas (the occurrence site data were downloaded from GBIF https://doi.org/10.15468/dl.s3mywg).

CBL, condylobasal length; CCL, condylo-canine length; ZYW, zygomatic width; IOW, interorbital width; BCW, braincase width; MAW, mastoid width; BCH, braincase height; CM^3L, maxillary toothrow length; C^1C^1W, width across the upper canines; M^3M^3W, width across the upper molars; CM_3L, mandibular toothrow length; and ML, mandible length. Morphologically similar and sympatric species were used for comparison (Appendix 2).

Results

Phylogenetic analysis and species delimitation

A BI tree for *Murina* was constructed based on the Cyt *b* gene (1041 bp). The tree mirrored the results from the study of Ruedi et al. (2012), with weak support for species relationships within *Murina*. The relationships between three putative new species and their sister taxa varied in support. *Murina* sp1. (*Murina chayuensis* sp. nov.) and *Murina* sp3 formed robust clades with *M. pluvialis* and *M. chrysochaetes*, respectively (BPP = 1.00), while the clade formed by *Murina* sp2 and *M. shuipuensis* had weaker support (BPP = 0.77) (Fig. 2). In addition, individuals of *M. leucogaster* were placed in two distinct clades (Fig. 2). The first clade included only *M. leucogaster* and formed a sister group with *M. fanjingshanensis*. The second clade included sequences initially identified as belonging to both *M. leucogaster* and *M. hilgendorfi* and formed a sister group with *M. bicolor*, *M. fanjingshanensis*, *M. leucogaster*, *M. shuipuensis*, *and Murina* sp2. According to Ruedi et al. (2012), individuals in the second clade labeled as *M. leucogaster* were actually *M. hilgendorfi*.

The genetic distance between *Murina* sp1 and *M. pluvialis* was 0.09, the distance between *Murina* sp2 and *M. shuipuensis* was 0.13, and the distance between *Murina* sp3 and *M. chrysochaetes* was 0.15 (Table 1). The molecular evidence thus suggests that three putative new species can be distinguished from other known species within the genus *Murina*.

The ASAP analysis identified 29 species partitions based on the best ASAP scores (Suppl. material 1: fig. S1). The method revealed two distinct phylogenetic species clades within *M. gracilis* and three within the morphospecies *M. huttonii* (Fig. 2 and Suppl. material 1: fig S1). The mPTP and bPTP tree-based analyses also identified 29 species partitions, consistent with the ASAP results (Fig. 2, Suppl. material 1: figs S2, S3). All three methods supported the partitioning of *Murina* sp1 (*Murina chayuensis* sp. nov.), *Murina* sp2, and *Murina* sp3 (Fig. 2).

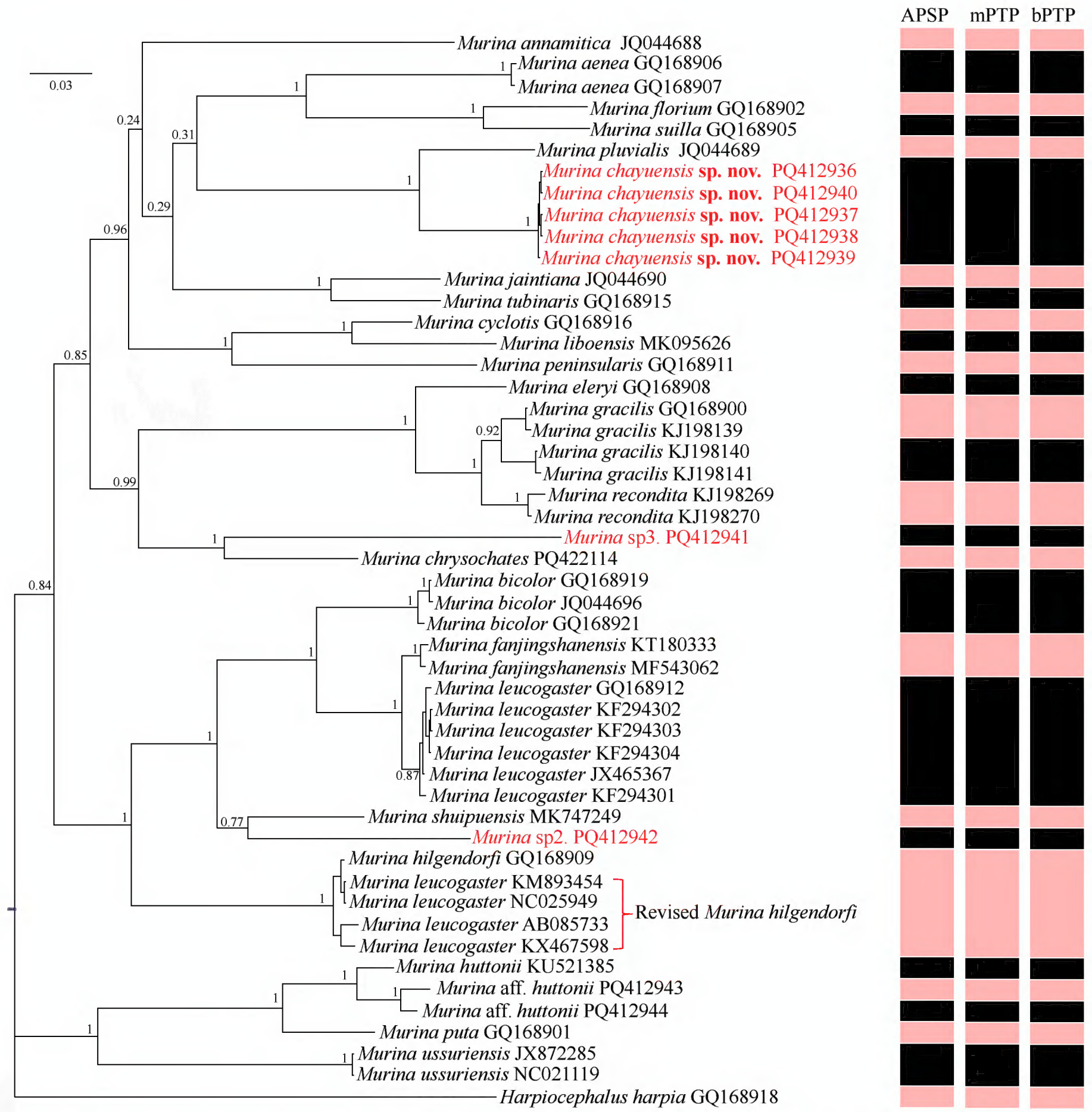

Figure 2. Bayesian inference (BI) tree and an assessment of *Murina* species delimitation using ASAP, mPTP, and bPTP based on the mitochondrial Cyt *b* gene. BI tree node numbers indicate the Bayesian posterior probability (BPP). The black and pink boxes denote the putative species identified by ASAP, mPTP, and bPTP.

Taxonomic treatment

Murina chayuensis Luo & Zhou, sp. nov.

https://zoobank.org/E258B6B5-57CB-49E3-BC47-BFD1CF37A8ED

Figs 3, 4, Suppl. material 1: table S1

Materials. ***Holotype.*** • XZ2023107 (36.51 mm FA and 16.83 mm GTL; Figs 3, 4) was collected by Pengfei Luo and Jiang Zhou on 17 August 2023, in Chayu County, Linzhi City, Xizang, China (28°29'51.12"N, 97°0'53.87"E, 1511 m a.s.l; Fig. 1). ***Paratypes.*** • Four specimens (XZ2023085, XZ2023086, XZ2023088, and XZ2023100) were collected by Pengfei Luo and Jiang Zhou from the same locality as the holotype (28°29'51.12"N, 97°0'53.87"E, 1511 m a.s.l; 28°29'1.47"N, 97°1'23.07"E, 1613 m a.s.l; Fig. 1).

Etymology. We discovered a new species in Chayu County that we named *Murina chayuensis* sp. nov. We propose the common English name "Chayu Tube-Nosed Bat" and the Chinese name "chá yú guǎn bí fú (察隅管鼻蝠)."

Diagnosis. The new species is a medium-sized bat in the genus *Murina* (FA: 33.49–36.51 mm; Table 2 and Suppl. material 1: table S1). Dorsal fur overall displays a tan color, with a few reddish-brown guard hairs. Dorsal fur has two color bands: black at the base and tan at the tip (Fig. 3A, B). Ventral fur overall is pale, with two color bands, a dark base covering approximately two-thirds and a whitish tip covering approximately one-third (Fig. 3C). The plagiopatagium is almost attached to the base of the claw (Fig. 3D). The skull is domed (Fig. 4C). The sagittal crest is absent, and the lambdoid

Table 1. Genetic distance based on the Kimura 2-parameter model between species calculated from Cyt *b* sequences.

ID	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	*M. annamitica*																									
2	*M. aenea*	0.18																								
3	*M. bicolor*	0.18	0.19																							
4	*M. cyclotis*	0.18	0.16	0.18																						
5	*M. eleryi*	0.18	0.17	0.20	0.18																					
6	*M. fanjingshanensis*	0.19	0.19	0.08	0.17	0.21																				
7	*M. florium*	0.18	0.16	0.18	0.18	0.18	0.18																			
8	*M. gracilis*	0.20	0.19	0.22	0.18	0.08	0.22	0.19																		
9	*M. hilgendorfi*	0.18	0.17	0.15	0.17	0.18	0.15	0.18	0.20																	
10	*M. huttonii*	0.20	0.19	0.19	0.17	0.19	0.20	0.20	0.18	0.20																
11	*M. jaintiana*	0.17	0.18	0.17	0.15	0.19	0.16	0.15	0.19	0.18	0.20															
12	*M. leucogaster*	0.19	0.18	0.09	0.16	0.20	0.02	0.17	0.21	0.14	0.19	0.16														
13	*M. liboensis*	0.18	0.18	0.20	0.08	0.20	0.19	0.18	0.20	0.19	0.19	0.17	0.18													
14	*M. peninsularis*	0.18	0.17	0.18	0.14	0.19	0.19	0.20	0.22	0.18	0.20	0.19	0.19	0.16												
15	*M. pluvialis*	0.17	0.18	0.19	0.18	0.20	0.19	0.19	0.19	0.19	0.20	0.17	0.20	0.17	0.18											
16	*M. puta*	0.19	0.20	0.18	0.18	0.18	0.19	0.20	0.17	0.18	0.08	0.20	0.18	0.19	0.19	0.21										
17	*M. recondita*	0.19	0.18	0.21	0.19	0.08	0.21	0.19	0.05	0.19	0.18	0.19	0.21	0.21	0.22	0.19	0.18									
18	*M. shuipuensis*	0.15	0.19	0.12	0.16	0.20	0.11	0.17	0.20	0.14	0.18	0.16	0.12	0.18	0.18	0.17	0.16	0.19								
19	*M. suilla*	0.19	0.14	0.21	0.17	0.19	0.19	0.08	0.20	0.18	0.20	0.17	0.19	0.17	0.19	0.18	0.21	0.19	0.17							
20	*M. tubinaris*	0.17	0.17	0.17	0.17	0.19	0.17	0.16	0.19	0.17	0.20	0.09	0.17	0.18	0.19	0.18	0.19	0.19	0.16	0.17						
21	*M. ussuriensis*	0.17	0.17	0.18	0.17	0.19	0.19	0.20	0.20	0.16	0.17	0.19	0.20	0.18	0.18	0.18	0.17	0.19	0.18	0.19	0.20					
22	*M. chayuensis* sp. nov.	0.17	0.18	0.18	0.17	0.20	0.18	0.17	0.19	0.19	0.19	0.17	0.18	0.17	0.17	0.09	0.19	0.20	0.17	0.18	0.17	0.17				
23	*M.* sp3.	0.19	0.20	0.19	0.20	0.18	0.20	0.21	0.19	0.18	0.21	0.19	0.20	0.20	0.19	0.20	0.20	0.19	0.20	0.23	0.19	0.18	0.19			
24	*M.* sp2.	0.20	0.19	0.15	0.16	0.20	0.13	0.18	0.22	0.15	0.20	0.19	0.13	0.19	0.17	0.20	0.18	0.22	0.13	0.19	0.18	0.20	0.19	0.20		
25	*M.* aff. *huttonii*	0.19	0.20	0.19	0.17	0.19	0.20	0.20	0.19	0.19	0.04	0.19	0.20	0.18	0.18	0.21	0.09	0.19	0.17	0.20	0.19	0.16	0.19	0.21	0.18	
26	*M. chrysochaetes*	0.16	0.18	0.17	0.16	0.16	0.17	0.19	0.17	0.17	0.14	0.18	0.17	0.18	0.16	0.17	0.14	0.16	0.17	0.19	0.17	0.15	0.18	0.15	0.18	0.15

crest is weakly developed (Fig. 4A, C). The first upper incisor (I^2) is obscured by the second upper incisor (I^3) in lateral view (Fig. 4C). The mesostyles of the first and second upper molars (M^1 and M^2) are well developed, with distinct cusps, and there is a W-shaped indentation on the outer side of the molars (Fig. 4B). The basal area of the second upper premolar (P^4) is comparable to that of the upper canine (C^1), whereas the basal area of the first upper premolar (P^2) is approximately two-thirds that of P^4 (Fig. 4B). The basal area of the lower M_1 and M_2 talonids is two-thirds of their respective trigonids, and the M_3 talonid is half of its trigonid (Fig. 4D, E).

In the phylogenetic analyses (Fig. 2), all specimens of *Murina chayuensis* sp. nov. formed a clade and a distinct lineage sister to *M. pluvialis* with a posterior probability of 1, indicating that *Murina chayuensis* sp. nov. and *M. pluvialis* have differentiated but share a close phylogenetic relationship. However, the genetic distance between *Murina chayuensis* sp. nov. and *M. pluvialis* was 0.09, a value that is greater than those between *M. fanjingshanensis* and *M. bicolor* (0.08), between *M. liboensis* and *M. cyclotis* (0.08), between *M. suilla* and *M. florium* (0.08), and between *M. eleryi* and *M. gracilis* (0.08) (Table 1). Therefore, the validity of *Murina chayuensis* sp. nov. as a distinct species is established.

Description. *Murina chayuensis* sp. nov. possesses a "*cyclotis*-type" dentition, characterized by the I^3 obscuring the I^2, with the basal area of P^2 being two-thirds or more than that of P^4 (Corbet and Hill 1992; Koopman, 1994; Francis et al. 2010; Son et al. 2015). There is black facial hair surrounding the mouth and eyes (Fig. 3A). There is a rounded auricle with no visible incision on the posterior edge (Fig. 3A). On the dorsal surface, the hair color displays two bands, being black at the base and tan at the tip, with a few reddish-brown guard hairs (Fig. 3A, B). The upper surfaces of the uropatagium, hind limbs, and feet are densely covered in uniformly tan hairs. Short golden hairs occur on the dorsum of the forearms and thumbs but not on the metacarpals. On the ventral surface, the hairs are also bicolored, dark brown at the base and whitish at the tip (Fig. 3C). The plagiopatagium is attached to the base of the claw (Fig. 3D).

The skull is medium-sized, with a GTL of 15.75–16.83 mm. The CM^3L is 5.14–6.06 mm, which is 0.31–0.37 of the GTL (Table 2 and Suppl. material 1: table S1). The rostrum is flat, and the braincase is domed (Fig. 4C), with a relatively high braincase (BCH/BCW: $\bar{x}$ = 0.98; sd = 0.07; range = 0.87–1.06; n = 5; Table 2 and Suppl. material 1: table S1). The interorbital region is deeply concave (Fig. 4A). The forehead is slowly and smoothly rising from the rostrum to the braincase (Fig. 4C). The zygoma is not strong without a dorsal process (Fig. 4C). The prepalatal emargination is equal in depth and width, ending at the level of middle of the upper canine (C^1) (Fig. 4A, B). The postpalatal emargination is width over depth (Fig. 4B). A pair of basisphenoid pits are well defined, tear-drop shaped, and deep. (Fig. 4B). The sagittal crest is absent, and the lambdoid crest is weakly developed (Fig. 4A, C). The maxillary toothrows are convergent anteriorly (C^1C^1W/M^1M^1W: $\bar{x}$ = 0.69; sd = 0.02; range = 0.68–0.73; n = 5). The dental formula is I2/3 C1/1 P2/2 M3/3 = 34 (Fig. 4B, D). The I^2 is largely obscured by I^3 in the side view (Fig. 4C). P^2 is shorter than P^4; P^4 is approximately two-thirds of C^1, and P^2 is half

Figure 3. External characteristics of *Murina chayuensis* sp. nov. (XZ2023107) **A.** Face; **B.** Dorsal fur; **C.** Ventral fur; and **D.** Hindfoot.

of C^1 in height (Fig. 4C). The basal area of P^4 is comparable to that of C^1 (Fig. 4B). The paracones of the first and second upper molars (M^1 and M^2) are higher than their respective metacones. The third upper molar (M^3) retains only the paracone, parastyle, and protocone. The mesostyles of M^1 and M^2 are well developed, with distinct cusps. There is a W-shaped indentation on the labial sides of M^1 and M^2 (Fig. 4B, C).

The mandible is delicate, with 10.22–11.55 mm of ML (Table 2 and Suppl. material 1: table S1). The CM_3L is 5.23–6.67 mm, which is 0.48–0.61 of ML (Table 2 and Suppl. material 1: table S1). C_1 is higher than the lower first and second premolars (P_2 and P_4) (Fig. 4E). P_2 and P_4 are subequal in height (Fig. 4E). The basal area of P_2 is approximately two-thirds that of P_4 (Fig. 4D). The lower first and second molars (M_1 and M_2) possess the structural type of nyctalodonty (Fig. 4D). The entoconids of M_1 and M_2 are developed, with distinct cusps (Fig. 4D). The basal area of the lower M_1 and M_2 talonids is two-third their respective trigonids, and the M_3 talonid is half of its trigonid (Fig. 4D, E).

Comparisons with other taxa. *Murina chayuensis* sp. nov. possesses "*cyclotis*-type" dentition. Therefore, it is readily distinguished from all species with the "*suilla*-type" dentition. Within all recognized species that have "*cyclotis*-type" dentition, *M. liboensis* and *M. rozendaali* are much smaller and can be easily distinguished from the new species (FA lower than 33.5 mm; Table 2). *M. harrisoni*, *M. tiensa*, *M. cyclotis*, *M. fionae*, *M. guilleni*, and *M. peninsularis* either possess unicolored pale fur or indistinct color bands on the ventral side (vs. distinct bicolor; Fig. 3C), and they possess a developed sagittal crest (vs. absent; Figs 4A, C, 5B–E, I, L). Compared with *Murina chayuensis* sp. nov., *M. harrisoni* and *M. tiensa* also have larger skulls, longer CM^3L and CM_3L (Table 2), and a flatter braincase (vs. domed; Figs 4C, 5E, L). In addition, *M. cyclotis*, *M. fionae*, *M. guilleni*, and *M. peninsularis* lack mesostyles of M^1 and M^2 (vs. developed; Figs 4B, 5B–D, I). Of the above species, only *M. cyclotis* occurs in the southeastern QTP and adjacent areas (Fig. 1); this species can also be distinguished from *Murina chayuensis* sp. nov. by smaller FA (Table 2) and more developed P^2 (basal area: P^2 and P^4 are equal in *M. cyclotis* vs. P^2 is two-thirds of P^4 in *Murina chayuensis* sp. nov.; Figs 4B, 5B).

Other *Murina* species possess "*cyclotis*-type" dentition that is distributed in the southeastern QTP, including *M. huttonii* and *M. pluvialis*. The ear of *M. huttonii* is longer at 16.20–17.40 mm (vs. 13.72–14.82 mm; Table 2); the interfemoral membrane is extensively covered with reddish-brown hairs (vs. absent); and the skull is longer, with GTL 17.90–18.40 mm (vs. 15.75–16.83 mm; Table 2). Furthermore, the prepalatal emargination is shallower, closing to the junction of C^1 and P^2 (vs. middle of C^1; Figs 4B, 5F); the talonids of M_1 and M_2 are only slightly less than their respective trigonids in length (vs. two-thirds; Fig. 4D). *M. pluvialis* as a sister taxon to *M. chayuensis* sp. nov. (Fig. 2), and these two species are similar in body size

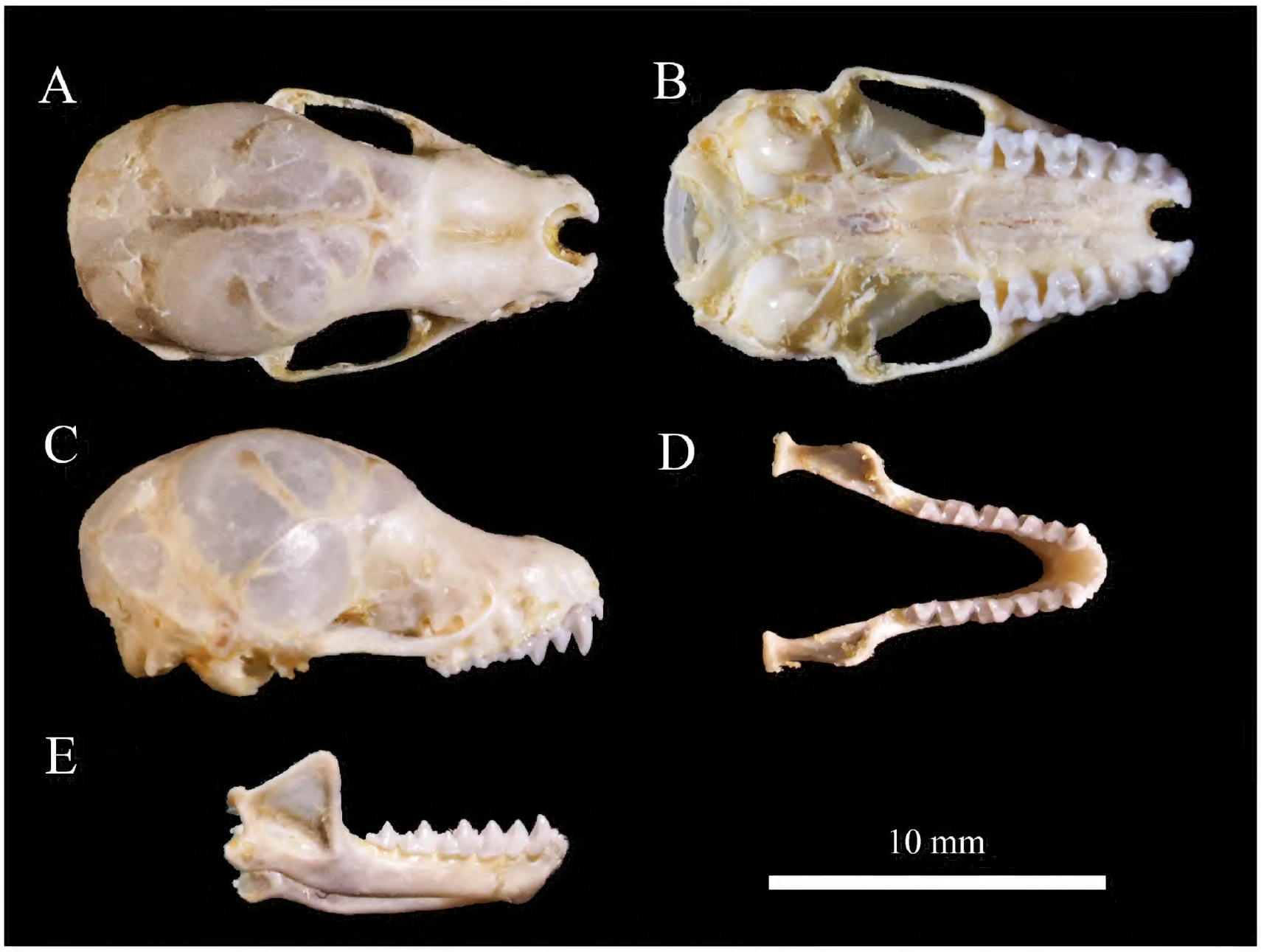

Figure 4. Cranial morphology of *Murina chayuensis* sp. nov. (XZ2023107) **A.** Cranium in dorsal view; **B.** Cranium in ventral view; **C.** Cranium in left side view; **D.** Mandible in dorsal view; and **E.** Mandible in left side view. Scale bar: 10 mm.

(Table 2). However, *M. pluvialis* has bright red dorsal fur without shiny guard hairs and silvery gray hair ventrally, clearly distinguishing it from the new species (vs. tan in the dorsal and whitish in the ventral hair, with the presence of reddish-brown guard hairs; Fig. 3A–C); the sagittal and lambdoid crests are more developed (vs. absent and weak; Figs 4A, C, 5J). Furthermore, the crown area between P^2 and P^4 has a distinct gap (vs. indistinct; Figs 4C, 5J); the mesostyles of M^1 and M^2 are reduced (vs. well developed; Figs 4B, 5J); and the indentation in the labial side is more U-shaped from the ventral view (vs. W-shaped; Figs 4B, 5J). In addition, the talonids of M_1 and M_2 are equal to their respective trigonids in length (vs. two-thirds; Figs 4D, E, 5J).

M. lorelieae and *M. annamitica* are similar to *Murina chayuensis* sp**. nov.** in fur color and cranial morphology. However, both species have a shorter FA (Table 2), and the prepalatal emargination is shallower, ending at the level of the junction of C^1 and P^2 (vs. middle of C^1; Figs 4A, B, 5A, H). In addition, *M. annamitica* shows slate gray basal fur dorsally (vs. black; Fig. 3B), and P^2 is equal to P^4 in height (vs. two-thirds; Figs 4C, 5A). Despite the lack of *M. lorelieae* in the phylogenetic analysis, it is also possible to distinguish *Murina chayuensis* sp. nov. by its dorsal fur having three color bands (vs. two color bands; Fig. 3B). The braincase is also more inflated, rising more abruptly from the rostrum (vs. slowly and smoothly rising; Figs 4C, 5H), and the lambdoidal is absent (vs. present; Figs 4A, C, 5H).

Distribution and ecology. To date, *Murina chayuensis* sp. nov. has only been found in Xiachayu Town, Chayu County, Xizang, China. The specimens were captured in harp traps set in mixed coniferous-broad-leaved forest at an altitude of approximately 1500–1600 m. This forest is near Xiachayu Town and local farms, where we also collected six species from five genera: *Murina* sp2, *M.* aff. *huttonii*, *Harpiola isodon*, *Rhinolophus ferrumequinum*, *Pipistrellus* sp., and *Myotis* sp.

Discussion

In this study, we described a new bat species, *Murina chayuensis* **sp. nov**. (*Murina* sp1), discovered in Xiachayu Town, Chayu County, Xizang, China. The identification was based on morphological characteristics (see Sec. 3.6) and genetic differences (see Sec. 3.1). The addition of this new species brings the total number of recognized *Murina* species to 42 (Wilson and Mittermeier 2019; Yu et al. 2020; Mou et al. 2024; Wang et al. 2024), with four species now identified in the QTP (Huang et al. 2008; Wang et al. 2024). The southeastern QTP, characterized by its relatively low elevation, deeply cut valleys, and diverse vertical climates, harbors complex ecosystems (Zhang et al. 2002). Recent taxonomic studies and intensified surveys have led to the discovery of several new species of small mammals in this region (Liu et al. 2022;

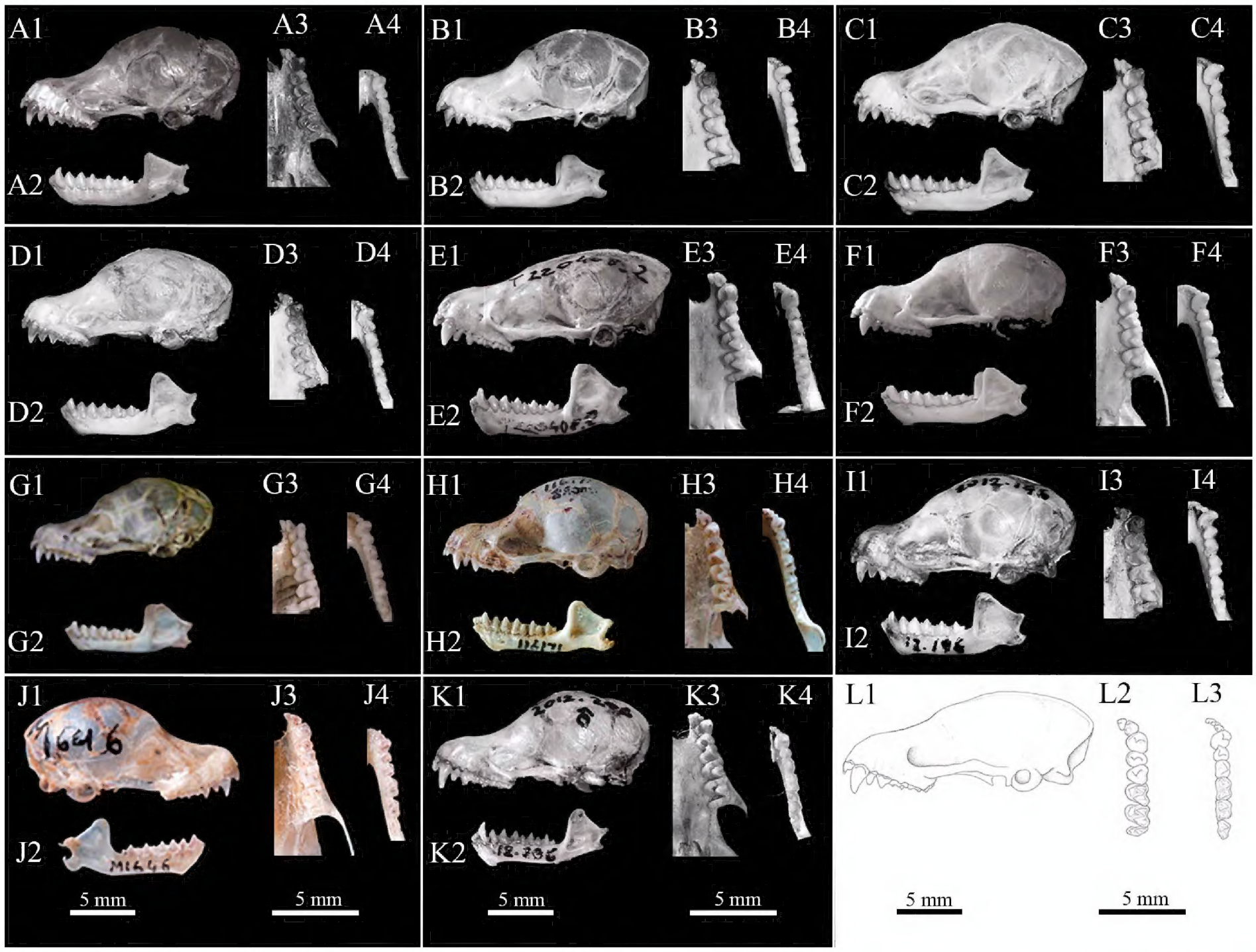

Figure 5. Cranial morphology of other *Murina* species with the "cyclotis-type" dentition, sourced from Eger & Lim, 2012; Reudi et al. 2012; Soisook, 2013; and Zeng et al. 2018. **A.** *M. annamitica* (PSUZC-MM2011.31); **B.** *M. cyclotis* (PSUZC-MM2006.179); **C.** *M. fionae* (field no. 025); **D.** *M. guilleni* (PSUZC-MM2010.22, holotype); **E.** *M. harrisoni* (field no. T.220408.2); **F.** *M. huttonii* (PSUZV-MM2011.33); **G.** *M. liboensis* (GZNU20160727022, holotype); **H.** *M. lorelieae* (ROM MAM 116171, holotype); **I.** *M. peninsularis* (PSUZC-MM2012.196); **J.** *M. pluvialis* (MHNg 1976.071, holotype); **K.** *M. rozendaali* (PSUZC-MM2012.206); and **L.** *M. tiensa* (HZM 2.38178, holotype). Scale bar: 5 mm.

Chen et al. 2024). Notably, the two distinct lineages identified as *Murina* sp2 and *Murina* sp3 may potentially represent two undescribed species of *Murina* (Fig. 2). Therefore, further specimen collecting and analysis are necessary for proper morphological description.

DNA barcoding, a molecular analysis tool, enables swift species identification (Francis et al. 2010; Csorba et al. 2011; Francis and Eger 2012). It has been instrumental in recognizing cryptic diversity. An example from bats is the *M. cyclotis* complex, which includes *M. cyclotis*, *M. peninsularis*, *M. fionae*, *M. guilleni*, *and M. liboensis* (Francis and Eger 2012; Soisook et al. 2013; Zeng et al. 2018). Nevertheless, morphological characters remain a vital criterion for taxonomic studies and species identification (Yu et al. 2020). Herein, we provide a key to the *Murina* species occurring in the southeastern QTP (Appendix 3; Table 2 and Suppl. material 1: table S2).

Based on dental characteristics, *Murina* bats have traditionally been divided into two species types, "*suilla*" and "*cyclotis*" (Corbet & Hill, 1992; Koopman, 1994). Based on the position of I^2 and I^3 and the crown area of P^2 and P^4 (Corbet & Hill, 1992), *Murina chayuensis* sp. nov. belongs to the "*cyclotis*" type. A cranial morphometric analysis of *Murina* species by Son et al. (2015) showed that the crown area of C^1 and P^4 is an important characteristic that distinguishes the "*suilla*" and "*cyclotis*" types. Therefore, we can confirm that *Murina chayuensis* sp. nov. is a member of the "*cyclotis*" type, as the crown area of C^1 is greater than that of P^4. However, the dental characteristics do not have strict phylogenetic correspondence (Francis et al. 2010; Son et al. 2015). The internal nodes in single segment-based phylogenetic trees are not robust in existing studies within the genus *Murina* (Ruedi et al. 2012; Tu et al. 2015; Yu et al. 2020). Thus, genome-level data and morphological characteristics are necessary to reconstruct a robust phylogenetic tree and supplement diagnostic keys. In addition, clarifying the phylogenetic relationships between species or types can contribute to a deeper understanding of the origins, dispersal patterns, and differentiation of *Murina* species.

Table 2. External and cranial measurements (in mm) of *Murina* species.

Species	Sex	FA	E	GTL	CBL	CCL	ZYW	IOW	BCW
M. aenea	♂♂ (n = 3)	35.00, 35.60 [2]	14.50, 15.00 [2]	16.95–17.73	15.73–16.19	14.97–15.55	10.29–10.76	4.71–4.87 [2]	8.15–8.38
	♀♀ (n = 4)	34.70–37.40	12.70–14.90	17.20–17.80 [3]	15.80–16.39 [3]	15.00–15.69 [3]	10.65 [1]	4.83 [1]	8.11
M. annamitica	♂♂ (n = 5)	30.00–30.90	13.10–14.00 [4]	16.00–16.20	14.30–14.80	\	8.70–9.00	\	\
	♀	32.2	14.5	16.4	15.1	\	9.4	\	\
M. cyclotis	♂♂ (n = 36)	29.40–33.00 [35]	12.00–17.60 [17]	15.86–17.08 [27]	14.00–15. 67 [27]	13.60–15.12	8.78–10.05 [35]	3.92–4.48	7.16–8.10
	♀♀ (n = 40)	31.60–36.80	12.70–16.00 [17]	16.60–18.18 [25]	14.95–16.86 [24]	14.34–16.17 [38]	9.33–10.43 [37]	3.99–4.52 [38]	7.40–8.17 [38]
M. fionae	♂♂ (n = 7)	34.50–36.30	12.10–15.60 [6]	17.53–19.26	15.99–17.49	15.32–16.87	9.78–10.89	4.26–4.85	7.75–8.39
	♀♀ (n = 6)	35.50–40.10	14.90–15.50 [3]	18.12–19.19	16.48–17.45	15.82–16.73	10.19–10.85	4.23–4.75	7.84–8.49
M. guilleni	♂♂ (n = 6)	31.90–34.00	11.40–15.20	16.40–17.54	14.93–15.83	14.47–15.19	9.29–9.93	4.24–4.44	7.65–7.82
	♀♀ (n = 3)	35.00–35.90	13.50–15.10	17.12–18.10	15.79–16.43	15.09–15.76	9.75–10.02	4.20–4.44	7.53–7.74
M. harrisoni	♂♂ (n = 5)	33.40–35.30	\	17.30–17.90	15.16–15.80	\	9.74–10.23	4.21–4.37	\
	♀♀ (n = 5)	36.80–39.50	\	18.51–18.91	16.20–16.65	\	10.68–10.91	4.23–4.58	\
M. huttonii	♂	35.10	16.70	17.90	16.50	\	9.20	\	\
	♀♀ (n = 2)	35.80, 36.40	16.20, 17.40	18.10, 18.40	16.5, 16.8	\	9.9, 10.02	\	\
M. lorelieae	♂♂ (n = 5)	29.77–31.35	13.74–14.91	14.82–15.43	14.24–14.28	\	7.86–8.46	\	6.87–7.48
	♀♀ (n = 8)	32.41–34.44	14.31–15.94	15.07–15.94	14.28–14.26	\	8.46–9.05	\	7.13–7.69
M. liboensis	♂♂ (n = 3)	28.16–30.98	11.52–12.92	15.54–16.52	10.16–11.54	\	7.75–9.32	\	6.32–7.45
	♀♀ (n = 2)	32.28, 32.64	13.84, 14.37	16.30, 16.97	13.35, 13.85	\	8.53, 9.32	\	7.67, 7.78
M. peninsularis	♂♂ (n = 22)	33.80–38.10 [22]	11.90–18.80 [13]	17.39–18.52	15.68–16.91	14.90–16.41	9.76–11.31	4.31–4.97 [22]	7.72–8.48
	♀♀ (n = 17)	34.50–39.40	13.00–17.00 [12]	17.59–19.33	16.11–17.69	15.53–16.89	10.12–11.22	4.46–4.88 [16]	7.70–8.58
M. pluvialis	♂	36.60	\	16.40	\	14.50	9.26	4.32	\
M. rozendaali	♂♂ (n = 13)	29.00–31.20 [9]	12.30–14.10 [7]	15.47–16.42 [7]	13.96–14.75 [7]	13.48–14.10 [7]	8.73–9.46 [7]	3.98–4.32 [6]	7.27–7.50 [7]
M. tiensa	Unknown (n = 4)	35.20–40.10	\	17.39–19.43	\	\	\	\	\
M. chayuensis sp. nov	♂♂ (n = 4)	33.49–35.12	13.72–14.47	15.75–16.35	12.91–15.07	12.58–14.74	8.57–8.94	4.45–5.16	7.25–7.46
	♀	36.51	14.82	16.83	14.25	13.09	9.45	5.18	7.42

Species	Sex	MAW	BCH	CM^3L	C^1C^1W	M^3M^3W	CM_3L	ML
M. aenea	♂♂ (n = 3)	8.61–8.85	6.92–7.48	8.15–8.38	8.15–8.38	6.51–6.62	6.51–6.62	11.99–12.71
	♀♀ (n = 4)	8.90	7.67	6.06	4.88	6.09	6.64	12.81
M. annamitica	♂♂ (n = 5)	7.50–8.00	\	5.00–5.20	3.80–4.10	\	5.00–5.70	\
	♀	8.1	\	5.3	4.5	\	5.9	\
M. cyclotis	♂♂ (n = 36)	7. 11–8. 48	6.08–7.22 [34]	5.12–5.68	3.73–4.27	5.07–5.79 [35]	5.57–6.18	10.52–11.68 [35]
	♀♀ (n = 40)	7. 64–8. 58 [38]	6.10–7.21 [37]	5.06–6.00 [38]	4.00–4.68 [37]	5.18–6.05 [38]	5.75–6.49 [37]	11.32–12.78 [37]
M. fionae	♂♂ (n = 7)	8.10–8.91	6.53–7.50	5.72–6.40	4.18–4.88	5.74–6.25	6.30–6.95	11.99–13.19
	♀♀ (n = 6)	8.22–8.92	6.98–7.48	5.78–6.32	4.32–4.72	5.71–6.24	6.33–6.89	12.56–13.01
M. guilleni	♂♂ (n = 6)	8.00–8.28	6.57–6.91	5.44–5.72	4.12–4.31 [5]	5.36–5.80	5.83–6.12	11.13–11.74
	♀♀ (n = 3)	8.18–8.43	6.78–7.10	5.50–5.91	4.28–4.44	5.68–5.87	6.01–6.43	11.95–12.34
M. harrisoni	♂♂ (n = 5)	8.54–8.93	\	5.63–6.00	\	\	6.32–6.83	\
	♀♀ (n = 5)	9.04–9.59	\	6.15–6.39	\	\	6.24–6.81	\
M. huttonii	♂	8.60	\	6.10	4.60	\	6.70	\
	♀♀ (n = 2)	8.50, 8.60	\	6.10, 6.10	4.60, 4.70	\	6.70, 6.90	\
M. lorelieae	♂♂ (n = 5)	6.92–7.47	\	4.70–4.83	3.50–3.80	5.02–5.48	4.73–5.15	9.67–9.98
	♀♀ (n = 8)	7.38–7.83	\	4.80–5.00	3.71–3.81	5.11–5.50	4.94–5.09	10.32–10.72
M. liboensis	♂♂ (n = 3)	5.02–6.53	5.84–7.46	4.26–5.13	3.04–3.78	4.19–5.32	4.84–5.53	9.67–11.53
	♀♀ (n = 2)	6.73, 7.12	7.51, 7.75	5.39, 5.58	3.99, 4.16	5.41, 5.75	5.74, 5.94	11.63, 12.28
M. peninsularis	♂♂ (n = 22)	8.32–9.39	6.79–8.22	5.52–6.09	4.28–5.28	5.45–6.22	5.94–8.02	11.25–12.92 [21]
	♀♀ (n = 17)	8.08–9.62	7.10–8.37	5.68–6.39	4.46–5.26 [16]	5.69–6.22 [16]	6.28–6.94 [16]	12.09–13.59
M. pluvialis	♂	7.78	6.43	5.49	4.21	5.52	5.93	11.18
M. rozendaali	♂♂ (n = 13)	7.34–7.74 [7]	6.15–6.86 [7]	5.20–5.50 [7]	3.77–4.14 [7]	5.17–5.35 [6]	5.62–6.02 [6]	10.55–11.22 [6]
M. tiensa	Unknown (n = 4)	\	\	5.82–6.68	\	\	6.30–7.21	11.95–13.62
M. chayuensis sp. nov	♂♂ (n = 4)	6.87–7.47	6.89–7.60	4.83–6.06	3.67–3.92	5.36–5.72	5.23–6.67	10.22–11.01
	♀	7.41	6.47	5.45	4.04	5.56	5.51	11.55

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Appendix 1

Table A1. The bat species used in the phylogenetic analyses.

Species	Locality	Cyt *b*	Reference
Harpiocephalus harpia	Taiwan, China	GQ168918	Han et al. 2009 (unpublished)
Murina aenea	Malaysia	GQ168906	Han et al. 2009 (unpublished)
M. aenea	Malaysia	GQ168907	Han et al. 2009 (unpublished)
M. annamitica	Laos	JQ044688	Ruedi et al. 2012
M. bicolor	Taiwan, China	GQ168919	Han et al. 2009 (unpublished)
M. bicolor	Taiwan, China	JQ044696	Ruedi et al. 2012
M. bicolor	Taiwan, China	GQ168921	Han et al. 2009 (unpublished)
Murian chayuensis sp. nov.	Xizang, China	PQ412936 (XZ2024085)	This study
Murian chayuensis sp. nov.	Xizang, China	PQ412937 (XZ2024086)	This study
Murian chayuensis sp. nov.	Xizang, China	PQ412938 (XZ2024088)	This study
Murian chayuensis sp. nov.	Xizang, China	PQ412939 (XZ2024100)	This study
Murian chayuensis sp. nov.	Xizang, China	PQ412940 (XZ2024107)	This study
M. chrysochaetes	Xizang, China	PQ422114 (XZ2023084)	This study
M. cyclotis	Mondolkiri, Cambodia	GQ168916	Han et al. 2009 (unpublished)
M. eleryi	Hunan, China	GQ168908	Han et al. 2009 (unpublished)
M. fanjingshanensis	Guizhou, China	KT180333	He et al. 2015
M. fanjingshanensis	Hunan, China	MF543062	Huang et al. 2018
M. florium	Papua New Guinea	GQ168902	Ruedi et al. 2012
M. gracilis	Taiwan, China	GQ168900	Ruedi et al. 2012
M. gracilis	Taiwan, China	KJ198139	Kuo et al. 2014
M. gracilis	Taiwan, China	KJ198140	Kuo et al. 2014
M. gracilis	Taiwan, China	KJ198141	Kuo et al. 2014
M. hilgendorfi	South Korea	GQ168909	Han et al. 2009 (unpublished)

Species	Locality	Cyt *b*	Reference
M. leucogaster (*hilgendorfi*)	South Korea	KM893454	Yoon & Park, 2014
M. leucogaster (*hilgendorfi*)	South Korea	NC025949	Yoon & Park, 2014
M. leucogaster (*hilgendorfi*)	Japan	AB085733	Sakai et al. 2003
M. leucogaster (*hilgendorfi*)	China	KX467598	Luo et al. 2016 (unpublished)
M. huttonii	China	KU521385	Zhang et al. 2016 (unpublished)
M. aff. *huttonii*	Xizang, China	PQ412943 (XZ2023052)	This study
M. aff. *huttonii*	Xizang, China	PQ412944 (XZ2023099)	This study
M. jaintiana	India	JQ044690	Ruedi et al. 2012
M. leucogaster	Henan, China	GQ168912	Han et al. 2009 (unpublished)
M. leucogaster	China	KF294301	Wang et al. 2013 (unpublished)
M. leucogaster	China	KF294302	Wang et al. 2013 (unpublished)
M. leucogaster	China	KF294303	Wang et al. 2013 (unpublished)
M. leucogaster	China	KF294304	Wang et al. 2013 (unpublished)
M. leucogaster	China	JX465367	Guo et al. 2012
M. liboensis	Guizhou, China	MK095626	Zeng et al. 2018
M. peninsularis	Mondolkiri, Cambodia	GQ168911	Han et al. 2009 (unpublished)
M. pluvialis	India	JQ044689	Ruedi et al. 2012
M. puta	Taiwan, China	GQ168901	Han et al. 2009 (unpublished)
M. recondita	Taiwan, China	KJ198269	Kuo et al. 2014
M. recondita	Taiwan, China	KJ198270	Kuo et al. 2014
M. shuipuensis	Guizhou, China	MK747249	Huang et al. 2019
M. suilla	Java, Indonesia	GQ168905	Han et al. 2009 (unpublished)
M. tubinaris	Mondolkiri, Cambodia	GQ168915	Han et al. 2009 (unpublished)
M. ussuriensis	South Korea	JX872285	Yoon et al. 2013
M. ussuriensis	South Korea	NC021119	Yoon et al. 2013
Murina sp2.	Xizang, China	PQ412942 (XZ2023094)	This study
Murina sp3.	Xizang, China	PQ412941 (XZ2023048)	This study

Appendix 2

The bat species used in morphological comparisons

Murina harrisoni **(Chen et al. 2018):**

Jiulianshan National Natural Reserve, Jiangxi, China: GZHU15090; GZHU15111; GZHU15124; GZHU15125; GZHU15142; GZHU15157; GZHU15159; GZHU15160; GZHU15161; GZHU15162.

Murina huttonii **(Francis & Eger, 2012):**

Uttar Pradesh, India: BMNH.79.11.21.685 (holotype); BMNH.14.7.10.32; Darjeeling: BMNH.16.3.25.25.

Murina annamitica **(Francis & Eger, 2012):**

Nakai Plateau, Khammouan Province, Laos: ROM 106492;
Ban Phoulan, Louangnamtha, Laos: ROM 118394;
Nam Et – Phou Louey, Houaphan, Laos: EBD 25753;
Tran Don, Quang Nam, Vietnam: ROM 111361;
Binh Phuoc Province, Vietnam: ZMMUS-184673;
Annamite Mountains, Bolokhamxai, Laos: ROM 106467 (holotype).

Murina aenea **(Soisook, 2013):**

Halabala Wildlife Research Station, Wang, Narathiwat, Thailand: PSUZC-MM2012.211, ♀PSUZC-MM2005.6, PSUZC-MM2012.209, PSUZC-MM2012.210; **Boripatr Waterfall, Ton Nga Chang WS., Rattaphum, Songkhla, Thailand:** PSUZC-MM2005.7; Ulu Chemperoh, Janda Baik, Pahang, Malaysia: BMHN.64.770; **Lampunat, Marawi, Kalimantan, Indonesia:** MZB30648.

Murina fionae **(Soisook, 2013):**

Tam Tri, Tam Ky, Quang Nam, C. Vietnam: field number 025; ♂field number 12; ♂field number 18; **Phong Nha, C. Vietnam:** HZM.8.31764; HZM.6.31759; HZM.7.31762; **Huong Hoa Nature Reserve, Quang Tri, C. Vietnam:** HNHM.2007.50.3; HNHM.2007.50.4; **Pu Mat NP., Nghe An, C. Vietnam:** HZM.10.31776; **Kon Cha Rang Nature Reserve, Gai Lai, C. Vietnam:** HZM.11.32353; **Ke Bang, Quang Binh, C. Vietnam:** HZM.4.31761; **Pu Huong, Nghe An, C. Vietnam:** HNHM.2008.23.7; **Ngoc Linh Nature Reserve, 10 Km SW Nuoc Xa, Quang Nam, C. Vietnam:** ROM MAM 111292; **Seima BCA, Mondol Kiri, E. Cambodia:** HNHM.2005.81.16.

Murina guilleni **(Soisook, 2013):**

Rajjaprabha Dam, Ban Takhun, Surat Thani, S. Thailand: PSUZC-MM2010.22 (holotype), PSUZC-MM2010.23 (paratype); **Ton Tae Waterfall, Pa Lien, Trang, S. Thailand:** PSUZCMM2012.7 (paratype); **Khao Nor Chuchi Reserve (=Khao Pra Bang Kram WS.), Krabi, S. Thailand:** ROM110439; **Wang Tai Nan Waterfall, Manang, Satun, S. Thailand:** PSUZCMM 2013.15 (paratype); **Ban Ton St., Khao Bantad WS, Phattalung, S. Thailand:** PSUZC-MM2012.8; **Yaroi**

Waterfall, Taleban NP., Satun, S. Thailand: PSUZC-MM2008.3; **Ban Vang Pha, Songkhla, S. Thailand:** PSUZCMM2007.350; **Rajjaprabha Dam, Ban Takhun, Surat Thani, S. Thailand:** PSUZC-MM2011.42; **Makling Waterfall, Rattaphum, Songkhla, S. Thailand:** PSUZC-MM2007.154; **Great Nicobar Island, Nicobar Islands, India:** HZM.14.35312 (holotype of M. sp. nov [A] subsp. nov.); **Tillanchong, Nicobar Islands, India:** HZM.12.35277 (paratype); **Camorta Nicobar Islands, India:** HZM.13.35278; **Bompuka, Nicobar Islands, India:** HNHM.2004.13.1 (paratype); **Trinket, Nicobar Islands, India:** HZM.15.35319 (paratype).

Murina cyclotis **(Soisook, 2013):**

Darjeeling, NE. India: BMNH.9.4.4.4 (holotype); **Gopaldara, Darjeeling, NE. India:** BMNH.16.3.25.28; **Pashok, Darjeeling, NE. India:** BMNH.16.3.25.29; **Teesta Valley, West Bengal, NE. India:** BMNH.20.6.24.1; **Mousakande, Gammaduwa, Sri Lanka:** BMNH.31.9.4.2 (holotype of M. eileenae); **Island Jungle Resort, Chitwan NP, Nepal:** BMNH.59.5.31.63; BMNH.66.5543; BMNH.72.42.56; ♂HNHM.98.7.3; **Madanyan Forest, Manse Township, Kachin, N. Myanmar:** HZM.17.35961; **Sumka Uma, Kachin, N. Myanmar:** BMNH.50.484; **Chin Hills, W. Myanmar:** BMNH.16.3.26.3; **50 miles from Kindat, Sagaing, W. Myanmar.:** BMNH.16.3.26.4; BMNH.16.3.26.89; **Hainan Island, China:** field number B050023; **Hy Nature Reserve, Bac Kan, N. Vietnam:** NF.160906.4; NF.170906.5; NF.030706.6; NF.170906.4; NF.230706.4, Kim; **Ke Bang, Quang Binh, C. Vietnam:** HZM.31760; **Pac Ban Village, Tuyen Quang, N. Vietnam:** HNHM.98.3.3; **Ben En NP., Thanh Hoa, Vietnam:** HNHM.2000.84.3; **Son La, N. Vietnam:** HNHM.2010.42.3; field number T.291107.3; field number T.241107.2; field number T.251107.1; **Bai Tu Long NP, Quang Ninh, N. Vietnam:** field number T.050808.8; **Cat Ba Island, Hai Phong, N. Vietnam:** field number T.120806.2; field number T.230408.1; field number T.220908.1; **Than Sa, Thai Nguyen, N. Vietnam:** field number 11; **Pu Hoat NR., Nghe An, C. Vietnam:** field number B46; **Cuc Phong NP., Ninh Binh, N. Vietnam:** HZM.1.30708; HNHM.208.23.1; **Pu Mat NP., Nghe An, C. Vietnam:** HZM.3.31526; HZM.9.31777; **Na Hang NR., Tuyen Quang, N. Vietnam:** BMNH.1997.384; **Me Linh, Vinh Phuc, N. Vietnam:** field number T85; field number T03; field number T.270308.2; **Ba Be NP., Bac Kan, N. Vietnam:** HNHM.2007.27.7; ♀NTS1597; **Tam Dao, Vinh Phuc, N. Vietnam:** field number T.010908.10; ♀field number T.010908.6; **Phuong Vien, Phu Tho, N. Vietnam:** field number T.210708.2; field number T.260607.2; field number T.270607.1; PSUZC-MM.2011.54; **Tamtri, Tam Ky, Quang Nam, C. Vietnam:** field number T.290708.6, Xuan Son, Phu Tho, N. Vietnam; ♀field number 06; **Ban Vieng, Khammouan, C. Laos:** BMNH.1999.854; **Tham Houay Si, 6.5 km SW. of Ban Vieng, Khammouan, C. Laos:** BMNH.1999.51; **Vang Vieng, Vientiane, C. Laos: field number BD100320.2;** ♀field number BD100320.5; **Phou Khao Kouay, Vientiane, C. Laos:** ROM MAM 110673; **Ban Keng Bit, Nam Kading, Khammouan, C. Laos:** SMF85753; **Sopkhang, Phongsaly, N. Laos:** MHNG.1926.033; **Doi Inthanon NP., Chom Thong, Chiang Mai, N. Thailand:** BMNH.82.164; **Tham Tab Tao, Fang, Chiang Mai, N. Thailand:** BMNH.78.2383; **Doi Pha Hom Pok, Fang, Chiang Mai, N. Thailand:** BMNH.82.165; **Chiangdao WS, Chiang Mai, N. Thailand:** PSUZCMM2011.32; **Klong Lan NP., Kampangphet, NW. Thailand:** THNHM-M-821; **Phu Suan Sai NP., Na Haew, Loei, NE. Thailand:** PSUZC-MM2006.179; PSUZCMM2006.178; **Phu Rua, Loei, NE. Thailand:** TISTR54-7170; **Mo Sing To, Khao Yai NP., 153 Nakhon Ratchasima, NE. Thailand:** THNHM-M-735; **Dong Sua Parn, Khao Yai NP., Nakhon Ratchasima, NE. Thailand:** THNHM-M-775; **Klong Klang Khao Ang Ru Nai WS., Chacherngsao, SE. Thailand:** PSUZC-MM.2005.203; **Phnom Samkos, Pursat, W. Cambodia:** HNHM.2007.49.10; **Seima BCA, Mondol Kiri, E. Cambodia:** HNHM.2006.34.38; HNHM.2005.81.33; HNHM.2005.81.48; **Bokor NP., Kampot, SW. Cambodia:** HNHM.2006.34.2.

Murina peninsularis **(Soisook, 2013):**

Khao Pra Bang Kram WS, Klong Tom, Krabi, S. Thailand: PSUZC-MM.2012.9; ♂PSUZC-MM2012.11; ♂PSUZCMM2012.12; ♀PSUZC-MM2012.14; **Huay Lek, Khao Nan NP., Nop Pitam, Nakhon Sithammarat, S. Thailand:** PSUZC-MM2007.349; **Khao Pu Khao Ya NP., Phattalung, S. Thailand:** PSUZC-MM 2011.29; **Kachong, Khao Bantad WS., Trang, S. Thailand:** PSUZC-MM2007.348; **Taleban NP., Satun, S. Thailand:** PSUZC-MM2006.160; **Talow Udang St., Tarutao Island, Satun, S. Thailand:** PSUZC-MM2008.137; **Pha Dum Waterfall, Ton Nga Chang WS, Songkhla, S. Thailand:** PSUZC-MM2012.16; PSUZC-MM2012.10; PSUZC-MM2012.12; PSUZC-MM2012.15; **Ton Nga Chang WS, Songkhla, S. Thailand: Hala-Bala WS., Wang, Narathiwat, S. Thailand:** PSUZC-MM2007.336; PSUZC-MM2011.30; PSUZC-MM2006.120; PSUZCMM2012.155; PSUZC-MM2012.156; PSUZC-MM2012.13; ♂PSUZC-MM2012.196; ♀PSUZC-MM2012.212; ♀PSUZCMM2012.213; **Ulu Chemperoh, Janda Baik, Pahang, peninsular Malaysia:** BMNH.64.771 (holotype); BMNH.64.772 (paratype); **Gunong Benom Base Camp, Bentong, Pahang, peninsular Malaysia:** BMNH.73.630; BMNH.67.1607; **Taman Negara, Pahang, peninsular Malaysia:** TK153526,; **Kuala Lompat, Pahang, peninsular Malaysia:** CMF920703-03; CMF920705-03; **Krau Wildlife Reserve, Pahang, peninsular Malaysia:** S401006; **Penang, peninsular Malaysia:** BMNH.1880.744; **Sungai Relembany Camp, Ulu Setiu, Besut, Terengganu, peninsular Malaysia:** BMNH.75.1294; **Pahang, peninsular Malaysia:** BMNH.73.631; **Batu Pahat, Kangar, Perlis, peninsular Malaysia:** BMNH.68.845;

Fraser Hill, Selangor, peninsular Malaysia: BMNH.64.773; **Lojing Highlands, Kelantan, peninsular Malaysia:** TK172744; **Melinau, Gunung Mulu NP., Sarawak, Borneo:** BMNH.78.1543; **Sepilok, Sabah, Borneo:** BMNH.82.556; BMNH.84.2019; TK168706; **Lumerau, Sabah, Borneo:** BMNH.84.2020.

Murina lorelieae **(Eger & Lim, 2011; Li et al. 2017):**

Diding Headwater Forest Nature Preserve, Guangxi Zhuang Autonomous Region, China: ROM MAM 116171 (holotype);
Ailao Nature Reserve, Yunnan Province, China: GZHU14231, GZHU14261, GZHU14268, GZHU14270, GZHU14271, GZHU14275, GZHU14279, GZHU14280, GZHU14281, GZHU14282.

Murina liboensis **(Zeng et al. 2018):**

Libo County, Guizhou Province, China: N20160727021 (paratype); N20160727022 (holotype); N20160727023 (paratype); N20160727024 (paratype); N20160727025 (paratype).

Murina rozendaali **(Soisook, 2013):**

Halabala Wildlife Research Station, Wang, Narathiwat: PSUZC-MM2012.206, PSUZC-MM2012.207, PSUZC-MM2012.208, field number PS130824.3, field number PS130824.4, field number PS130824.6, field number PS130824.7; **Gomantong, Sabah, Malaysia:** BMNH.83.360 (holotype), BMNH.84.2025; **Krau Wildlife Reserve, Malaysia:** Pahang BMNH.1999.300, BMNH.1999.301; **Park Monggis Substation, Kinabalu NP., Sabah, Malaysia**: TTU-M 108241; **Suatan, Kaltim, Kalimantan, Indonesia:** MZB26735; **Way Canguk, Lampung, Sumatra, Indonesia:** MZB34991.

Murina tiensa **(Csorba et al. 2008):**

Na Ri district of Kim Hy Nature Reserve, Bac Kan Province, Vietnam: HZM.2.38178 (holotype); **Bach Thong district of Kim Hy Nature Reserve, Bac Kan Province, Vietnam:** HNHM 2007.28.1 (paratype); **Na Ri district of Kim Hy Nature Reserve, Bac Kan Province, Vietnam:** NF.301006.1 (paratype); **Pu Mat National Park, Nghe An Province, Vietnam:** HZM 1.31525.

Murina aurata **(Maeda 1980):**

Moupin, Sichuan, China: 1870-590 (holotype); 1870-590a (paratype).

Murina pluvialis **(Ruedi et al. 2012):**

Khasi Hills, Meghalaya, India: MHNG1976.071.

Murina jaintiana **(Ruedi et al. 2012):**

Jaintia Hills, Meghalaya, India: MHNG1976.072; Chin Hill, Chin State, Myanmar: BM(NH) 16.3.26.5; BM(NH) 16.3.26.7; BM(NH) 16.3.26.8; BM(NH) 16.3.26.85; BM(NH) 16.3.26.86; BM(NH) 16.3.26.87; BM(NH) 16.3.26.88; HNHM2000.20.1.

Murina hkakaboraziensis **(Soisook et al. 2017):**

Hkakabo Razi National Park, Putao Township, Kachin, Myanmar: PS160218.6 (holotype).

Murina eleryi **(Soisook, 2013):**

Doi Inthanon, Chom Thong, Chiang Mai, Thailand: BMNH.82.162 (labeled as M. aurata); **Kim Hy Nature Reserve, An Tunh Commune, Na Rai District, Bac Kan Province, Vietnam:** HZM.1.39006 (paratype); **exact locality not available, Vietnam:** field number T120 (ROM field no. 29013); **Muong Do Commune, Phu Yen District, Son La Province, Vietnam:** field number T.241107.1.

Murina jinchui **(Yu et al. 2020):**

Wolong, Sichuan, China: GZHU 14453 (paratype), GZHU 14454 (paratype), GZHU 14455 (paratype), GZHU 14463 (holotype), GZHU 14461 (paratype), GZHU 14462 (paratype)

Appendix 3

A key to the *Murina* species in the southeastern QTP

1	Crown area of C^1 approximately equal to or less than that of P^4; Crown area of P^2 approximately half or less than that of P^4; I^2 situated anterior to I^3 ..... suilla-type 2
–	Crown area of C^1 approximately equal to or less than that of P^4; Crown area of P^2 approximately two-thirds or more than that of P^4; I^2 situated lateral to I^3 ..... cyclotis-type 6
2	Dorsal fur with shiny guard hairs; 3
–	Dorsal fur without shiny guard hairs; 4
3	P^4 exceeds C^1 in height ..... *M. aurata*
–	P^4 is approximately equal to C^1 in height 5

4 Smaller size, FA less than 31.10 mm; domed braincase; less developed P^4 ..... *M. jaintiana*
– Larger size, FA more than 31.10 mm; braincase flat; more developed P^4 ..... *M. jinchui*
5 Mesostyles of M^1 and M^2 well developed, with a W-shaped indentation in the labial side; ventral fur whitish gray ..... *M. hkakaboraziensis*
– Mesostyles of M^1 and M^2 reduced, with a U-shaped indentation in the labial side; ventral fur creamy white..... *M. eleryi*
6 Smaller size, FA less than 33.00 mm in males and 36.80 mm in females 7
– Larger size, FA more than 33.00 mm in males and 36.80 mm in females 8
7 Mesostyles of M^1 and M^2 are well developed, with a W-shaped indentation in the labial side; ventral fur has distinct color bands ..... *M. lorelieae*
– Mesostyles of M^1 and M^2 reduced, with a U-shaped indentation in the labial side; ventral fur has indistinct color bands ..... *M. cyclotis*
8 Talonids of M_1 and M_2, approximately two-thirds that of trigonids; sagittal crest absent ..... *M. chayuensis* sp. nov.
– Talonids of M_1 and M_2, approximately equal to those of trigonids; sagittal crest developed 9
9 Mesostyles of M^1 and M^2 well developed, with a W-shaped indentation in the labial side; interfemoral membrane with reddish-brown hairs..... *M. huttonii*
– Mesostyles of M^1 and M^2 reduced, with a U-shaped indentation in the labial side; interfemoral membrane without reddish-brown hairs ..... *M. pluvialis*

Supplementary material 1

Additional information

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Explanation note: **fig. S1.** Results of the analysis of species definition using ASAP. **fig. S2.** Results of the analysis of species definition using bPTP. **fig. S3.** Results of the analysis of species definition using mPTP. **table S1.** External and cranial measurements (in mm) of each specimen from this study. **table S2.** External and cranial measurements (in mm) of 'suilla' type species distributed in Qinghai-Tibetan Plateau.

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